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A BACTERIOLOGICAL AND CELLULAR STUDY OF THE LUNG EXUDATE DURING LIFE IN LOBAR PNEUMONIA.*

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Recent investigations go to show that phagocytosis is one of the ways by which an animal combats a pneumococcus infection. But whether this method is the primary or most important reaction is still unsettled. Phagocytosis of pneumococci in the exudate of pneumonic lungs as seen after death is slight; well-preserved pneumococci within leukocytes are rarely found; pneumococci in various stages of disintegration are found more often. The following study was made to determine something as to the number of pneumococci and other bacteria in the consolidated lung throughout the disease during life; what relation, if any, this number may have to the invasion of the blood and the termination of the attack, and to analyze more closely, if possible, the mechanism by which the pneumococci are destroyed.

The following procedure was used. The skin overlying the point chosen for puncture was sterilized by means of 95 per cent carbolic acid and a sterile alcohol sponge or by means of the latter alone, in which case the superficial epithelium was rubbed off. The patient was cautioned against taking a sudden deep inspiration as the needle was passed into the lung. The upper border of the rib was used as a guide and the puncture made with an ordinary antitoxin needle. Its length being only 3.5 cm., the puncture of a good-sized artery in the lung was impossible. The flexible rubber connection between the needle and the small sterile pipette avoided tearing the lung during the exertion of ordinary breathing. The pain was trivial and no untoward results occurred. A tight-fitting metal syringe was used to produce strong suction. In this way a small amount of the exudate was aspirated into the needle or pipette, and smears and blood-agar plate cultures made immediately.

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The amount of material used for the cultures after making the smears was necessarily small but sufficient to estimate roughly the number of viable organisms, as shown by the results of cultures from simultaneous punctures of the same lobe; moreover, the number of cocci in the smears seemed to correspond closely to those obtained in cultures.

Twenty-seven cases¹ have been studied, of which five died. The average age of those that recovered was 32 years, of those that died, 39 years. No particular reason for the fatal termination of the latter could be found outside of an overwhelming pneumococcus infection. Five of the 22 patients who recovered and three of those who died had two or more lobes involved. Multiple blood cultures were made in five instances. Three were positive on the third, fourth, or fifth days, while two were negative, one during, the other, the day after, crisis. In each instance, when the blood contained pneumococci the material from the lung yielded a large number of organisms, and when the blood was sterile the cultures from the consolidated lung likewise proved sterile. Of 48 punctures the exudate of 26 showed viable pneumococci, while in 22 it remained sterile. The pneumococcus was present in pure culture in every instance except in one fatal case where a moderate number of colonies of *Streptococcus pyogenes* were found. Occasionally a few colonies of staphylococci and saprophytic bacilli were found, but these were looked on as accidental contaminations from the skin or air. *Bacillus mucosus* and *Streptococcus mucosus* were not found.

Positive cultures were obtained at all stages of the disease, but the percentage of positive results was much higher in the early stages (up to the fifth or sixth day) in those that recovered and throughout the course in those that died. The number of pneumococci early in the attack was equally great in the fatal and non-fatal cases. Mild cases at this time appear to have as many pneumococci as the more severe. In those with a favorable termination the number of pneumococci usually gradually diminish as a crisis is reached, although at times the numbers drop abruptly. Only six out of 20 punctures made during and after crisis yielded

¹ Only typical cases of lobar pneumonia were selected in the wards of the Cook County Hospital, during the winter of 1909. I am greatly indebted to the members of the staffs for kind assistance.

pneumococci, only a few colonies developing in each instance; while in the patients who died the number of pneumococci became progressively greater until the time of death. This result is in keeping with the results of the blood cultures in this series and with the findings which I have made in a larger series, namely, that while blood cultures are positive in the fatal and non-fatal cases early in the disease, the number of positive cultures in the cases which recover becomes less as we approach crisis. A positive blood culture late in an attack of lobar pneumonia is therefore an unfavorable sign.

Giemsa's differential stain and Gram's method with eosin or carbol-fuchsin as counterstain were used in studying the smears. The predominating cell early in the attack is the polymorphonuclear neutrophile. Eosinophiles and basophiles are rarely found. The small lymphocytes are never numerous. Early in the attack large mononuclear cells are relatively few. They are well preserved and not phagocytic for leukocytes, but later, as crisis is reached, they become more numerous and during resolution are markedly phagocytic for leukocytes. At this stage the leukocytes and large mononuclear cells become vacuolated and show other evidences of disintegration. This is most pronounced when resolution is rapid.

In lungs obtained immediately after death, the leukocytes, pneumococci, and mononuclear cells were well preserved in the parts in the early stages of consolidation but showed marked evidences of disintegration in the parts in resolution. Here, too, phagocytosis of leukocytes by mononuclear cells was marked. As many as four disintegrating leukocytes, often containing disintegrating pneumococci, could be found in a single cell. The striking difference between the microscopic picture of the lung in resolution after crisis in the patient who recovers and the lung in resolution in the patient who dies with an extension into another lobe is the almost total absence of pneumococci in the former and the presence of great numbers in the latter. Indeed cultures show that the number of viable cocci is as great in the part in resolution after death as in the part more recently consolidated.

The changes in the character and kind of cells of the exudate seem to take place irrespective of the presence or absence of living

pneumococci. This observation would seem to argue against the idea that there is produced a large amount of a pneumococcal substance in the resolving lung and is in accord with the clinical observation that extension into another lobe is not infrequent during resolution of the lobe earlier involved.

The amount of phagocytosis of pneumococci is never very great. The smears from the punctures early in the attack show practically no phagocytosis, while those made later frequently show phagocytosis of pneumococci in various stages of disintegration. Whenever this is true a large number of disintegrating pneumococci are observed free in the exudate. This is seen best in the fatal cases, because in those which recover the number of pneumococci is usually too small after disintegration of cocci begins to study this point accurately. Certainly the amount of lysis of pneumococci in the lung seems as great in the patient that dies as in the one that recovers. Well-preserved pneumococci within leukocytes were seen in only five smears. The cocci in the exudate seem to be altered (as manifested by their loss of affinity for basic dyes) before they become susceptible to phagocytosis.

The most striking fact brought out by this study is the great difference in the number of viable pneumococci in the consolidated lung in the later stages of the disease in the cases which recover and in those which die: in the former they are relatively few, in the latter they are very numerous.